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¶ vi. NOTE.—*On the position of a crystal of sulphate of iron in the magnetic field.*

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Fig. 6.

2615. Though effects of the following nature are general, yet I think it convenient to state that I obtained them chiefly by the use of magnetic poles (2247.), the form of which is given in the plan and side view annexed (fig. 6.). The crystals submitted to their action were suspended by cocoon silk, so as to be level with the upper surface of the poles.

2616. A prismatic crystal of proto-sulphate of iron was selected, which was nearly 0·9 of an inch in length, 0·1 in breadth, and 0·05 in thickness; by examination the magnecrystallic axis was found to coincide with the thickness, and therefore to be perpendicular, or nearly so (2546.), to the plate. Being suspended as above described, and the magnet (2247.) excited by ten pair of Grove's plates, the crystal stood transverse, or with its *magnecrystallic axis* parallel to the axis of magnetic force, when the distance between the poles was 2·25 inches or more; but when the distance was about two inches or less, then it stood with its length axial, or nearly so, and its magnecrystallic axis therefore transverse to the lines of magnetic force. In the intermediate distances between 2 and 2·25 inches, the prism assumed an oblique position (2634.), more or less inclined to the axial line, and so passing gradually from the one position to the other. This intermediate distance I will for the present call *n* (neutral) distance.

2617. If the poles be two inches apart and the crystal be gradually lowered, it passes through the same intermediate oblique positions into the transverse position; or if the crystal be raised, the same transitions occur; at any less distance the changes are the same, but later. They occur more rapidly when the crystal is raised than when it is lowered; but this is only because of the unsymmetric disposition and intensity of the lines of magnetic force around the magnetic axis, due to the horse-shoe form of the magnet and shape of the poles. If two cylinder magnets with equal conical terminations were employed, there is no doubt that for equal amounts of elevation or depression, corresponding changes would take place in the position of the crystal.

2618. These changes however are not due to mere diminution of the magnetic force by distance, but to differences in the *forms* or *direction* of the resultants of force. This is shown by the fact that, if the crystal be left in its first position, and so pointing with the length axially, no diminution of the force of the magnet alters the position; thus, whether one or ten pair of plates be used to excite the magnet, the *n* distance (2616.) remains unchanged; and even descending to the use of an ordinary horse-shoe magnet, I have found the same result.

2619. Variation in the length of the prismatic crystal has an important influence

over the result. As the crystal is shorter the distance n diminishes, all the other phenomena remaining the same. A crystal 0·7 of an inch long, but thicker than the last, had for its maximum n distance 1·7 inch. A still shorter crystal had for its maximum n distance 1·1 inch. In all these cases variation of the force of the magnet caused no sensible change.

2620. Variation in that dimension of the crystal coincident with the magnecrystallic axis affected the n distance : thus, increase in the length of the magnecrystallic axis diminished the distance, and diminution of it in that direction increased the distance. This was shown in two ways ; first, by placing a second prismatic crystal by the side of the former in a symmetric position (2636.), which reduced the n distance to between 1·75 and 2 inches ; and next, by employing two crystals in succession of the same length but different thicknesses. The thicker one had the smaller n distance.

2621. Variation in the depth of the crystal, *i. e.* its vertical dimension, did not produce any sensible effect on the n distance : nor by theory should it do so, until the extension upwards or downwards brings the upper or lower parts into the condition of raised or depressed portions (2617.).

2622. Variation in the form of the poles affects the n distance. As they are more acute, the distance increases ; and as they are more obtuse up to flat-faced poles (2463.), the distance diminishes.

2623. With the shorter crystals, or with obtuse poles, it is often necessary to diminish the power of the magnet, or else the crystal is liable to be drawn to the one or other pole. This, however, may be avoided by employing a vertical axis which is confined below as well as above (2554.) ; and then the difference in *strength* of the magnet is shown to be indifferent to the results, or very nearly so.

2624. These effects may probably be due to the essential difference which exists between the ordinary magnetic and the magnecrystallic action, in that the first is *polar*, and the second only *axial* (2472.) in character. If a piece of magnetic matter, iron for instance, be in the magnetic field, it immediately becomes polar (*i. e.* has terminations of different qualities). If many iron particles be there, they all become polar ; and if they be free to move, arrange themselves in the direction of the axial line, being joined to each other by contrary poles ; and by that the polarity of the extreme particles is increased. Now this does not appear to be at all the case with particles under the influence of the magnecrystallic force ; the force seems to be altogether *axial*, and hence probably the difference above, and in many other results.

2625. Thus, if four or more little cubes of iron be suspended in a magnetic field of equal force (2465.), they will become polar ; if also four similar cubes of crystallized bismuth be similarly circumstanced, they will be affected and point. If the iron cubes be arranged together in the direction of the equatorial line, they will form

an aggregate in a position of unstable equilibrium, and will immediately, as a whole, turn and point with the length axially; whereas the bismuth cubes by such approximation will suffer no sensible change.

2626. The *extreme* (and the other) associated cubes of the elongated iron arrangement now have a polar force above that which they had before; and the whole group serves, as it were, as a conductor for the lines of magnetic power; for many of them concentrate upon the iron, and the intensity of power is much stronger between the ends of the iron arrangement and the magnetic poles, than it is in other parts of the magnetic field. Such is not the case with the bismuth cubes; for however they be arranged, the intensity of force in the magnetic field is, as far as experiments have yet gone, unaffected by them; and the intensity of the molecules of the crystals appears to remain the same. Hence the iron stands lengthways between the poles; the bismuth crystals, on the contrary, whether arranged side by side, as respects the magneocrystallic axis, so as to stand as to length equatorially; or end to end, so as to stand axially, are perfectly indifferent in that respect, vibrating and setting equally both ways.

2627. A given piece of iron when introduced into a field of equal magnetic force, and brought towards the pole, adheres to it and disturbs the intensity of the field, producing a pointed form of pole in one part with diverging lines of force: a crystal of bismuth vibrates with sensibly equal force in every part of the field (2467.), and does not disturb the distribution of the power.

2628. Considering all these actions and conditions, it appears to me that the occurrence of the *n* distance with a body which is at the same time magnetic and magneocrystallic, may be traced to that which causes them and their differences, namely, the *polarity* belonging to the magnetic condition, and the *axiality* belonging to the magneocrystallic condition. Thus, suppose an uniform magnetic field three inches from pole to pole, and a bar of magnetic matter an inch long, suspended in the middle of it; by virtue of the polarity it acquires, it will point axially, and carry on, or conduct, with its mass, the magnetic force, so much better than it was conducted in the same space before, that the lines of force between the ends of this bar and the magnetic poles, will be concentrated and made more intense than anywhere else in the magnetic field. If the poles be made to approach towards the bar, this effect will increase, and the bar will conduct more and more of the magnetic force, and point with proportionate intensity. It is not merely that the magnetic field becomes more intense by the approximation of the poles, but the proportion of force carried on by the bar becomes greater as compared to that conveyed onwards by an equal space in the magnetic field at its side.

2629. But if a similar bar of magneocrystallic substance be placed in the magnetic field, its power does not rise in the same manner, or in the same great proportion, by approximation of the poles. There can be no doubt that such approximation increases the intensity of the lines of force, and therefore increases the intensity of

the magneto-crystallic state; but this state does not appear to be due to polarity, and the bar does not convey more power through it than is conveyed onwards elsewhere through an equal space in the magnetic field. Hence its directive force does not increase in the same rapid degree as the directive force of the magnetic bar just referred to.

2630. If then we take a bar which, like a prism of sulphate of iron, is magnetic, and also magneocrystallic, having the magneocrystallic axis perpendicular to its length, such a bar, properly suspended, ought to have an n distance of the poles, within which the forces ought to be nearly in equilibrium; whilst at a greater distance of the poles, the magneocrystallic force ought to predominate; and at a lesser distance, the magnetic force ought to have the advantage; simply, because the magnetic force, in consequence of the true polarity of the molecules, grows up more rapidly and diminishes more rapidly than the magneto-crystallic force.

2631. This view, also, is consistent with the fact that variation of the force of the magnet does not affect the n distance (2618. 2619.); for, whether the force be doubled or quadrupled, both the magnetic and magneto-crystallic forces are at the same time doubled or quadrupled; and their proportion therefore remains the same.

2632. The raising or lowering of the crystal above or below the line of maximum magnetic force is manifestly equivalent in principle to the separation of the magnetic poles; and therefore should produce corresponding effects: and that is the case (2617.). Besides that, when the crystal is raised above the level of the poles, such resultants of magnetic force as pass through it, are no longer parallel to its length, but more or less curved, so that they probably cannot act with the same amount of power in throwing the whole crystal into a consistent polarized magnetic condition, as if they were parallel to it: whereas, as respects the induction of the magneto-crystallic condition, each of the particles appears to be affected independently of the others; and, therefore, any loss of an effect dependent upon joint action would not be felt here.

2633. M. PLÜCKER told me, when in England in August last, that the repulsive force on the optic axis diminishes and increases less rapidly than the magnetic force, by change of distance; but is not altered in its proportion to the magnetic force by employing a stronger or weaker magnet. This is manifestly the same effect as that I have been describing; and makes me still more thoroughly persuaded that his results and mine are due to one and the same cause (2605. 2607.).

2634. I have said that, within the n distance, the crystal of sulphate of iron pointed more or less obliquely (2616.); I will now state more particularly what the circumstances are. If the distance n be so adjusted, that the prismatic crystal, which is at the time between the magnetic poles, shall make an angle of 30° (or any quantity) with the axial line; then it will be found that there is another stable position, namely, the diametral position (2461.), in which it can stand; but that the obliquity

is always on the same side of the axial line ; and that the crystal will not stand with the like obliquity of 30° on the opposite side of the magnetic axis.

2635. If the crystal be turned 180° round a vertical axis, or end for end, then the inclination, and the direction in which it occurs, remain unchanged ; in fact, it is simply giving the crystal the diametral position. But if the crystal be revolved 180° round a horizontal axis ; either that coinciding with its length, which represents its maximum magnetic direction ; or that corresponding with its breadth, and therefore with the magnecrystallic axis ; then the inclination is the same in amount as before, but it is on the *other* side of the axial line.

2636. This is the case with all the prismatic crystals of sulphate of iron which I have tried. The effect is very determinate ; and, as would be expected, when two crystals correspond in the direction of the inclination, they also correspond in the position of their form and direction of the various planes.

2637. All these variations of position indicate an oblique resultant of setting force, derived from the joint action of the magnetic and magnecrystallic forces ; and would be explained by the supposition, that the magnecrystallic axis or line of maximum magnecrystallic force, was not perpendicular to the chief planes of the crystal (or those terminating it), but a little inclined in the direction of the length.

2638. Whether this be the case, or whether the maximum line of magnetic force may not, even, be a little inclined to the length of the prism ; still, the *n* distance supplies an excellent experimental opportunity of examining this inclination, however small its quantity may be ; because of the facility with which the influence of either the one or the other may be made predominant in any required degree.

Royal Institution,
December 5, 1848.

2639. *Note.* (2591.) Another supposition may be thrown out for consideration. I have already said that the assumption of a mere axial condition (2587. 2591.) would account for the set without attraction or repulsion. Now if we suppose it possible that the molecules should become polar in relation to the north and south poles of the magnet, but with *no mutual relation amongst themselves*, then the bismuth or other crystal might set as if induced with mere axial power : but it seems to me very improbable that polarities of a given particle in a crystal should be subject to the influence of the polarities of the distant magnet poles, and not also to the *like polarities* of the contiguous particles.—January 24, 1849.